

# Lecture Module - Frequency Filters

ME3023 - Measurements in Mechanical Systems

Mechanical Engineering

Tennessee Technological University

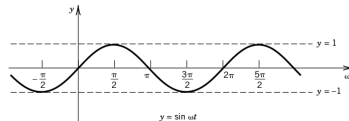
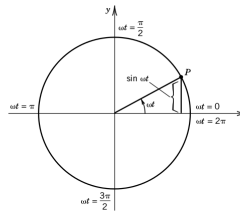
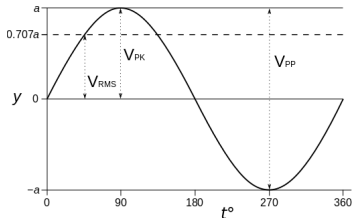
## Topic 1 - What is a Frequency Filter

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- Signal, Amplitude, and Frequency
- Filter Concept
- High-Pass, Low-Pass, and Band-Pass
- Applications
- MATLAB Activity

# Signal, Amplitude, and Frequency

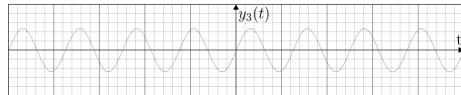
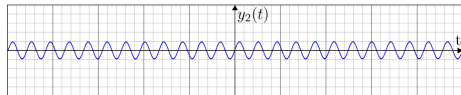
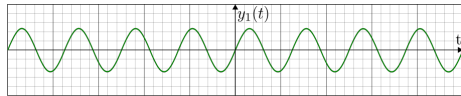
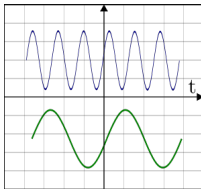
## Signal, Amplitude, and Frequency



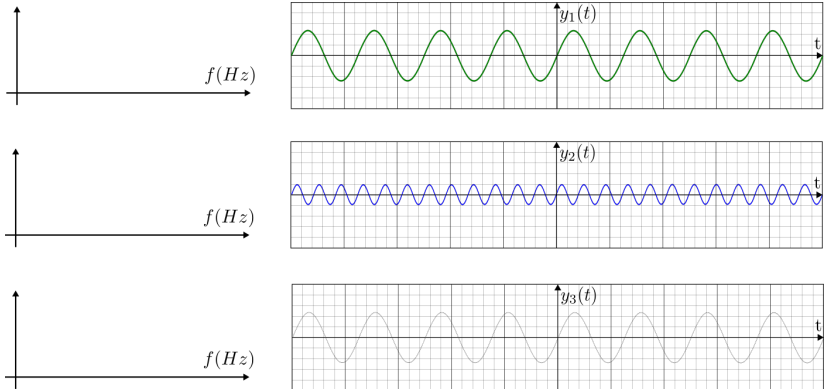
What is the relationship between the unit circle and frequency?

# Signal, Amplitude, and Frequency

Signals can be composed of multiple *frequency components*.  
(see Fourier Analysis Ch2).

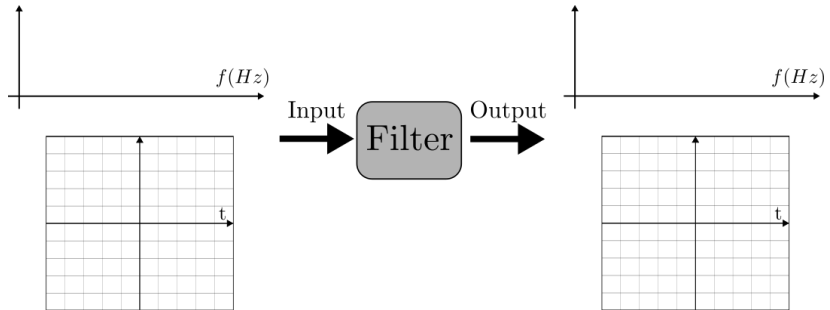


# Signal, Amplitude, and Frequency



# Filter Concept

A raw signal is input to a frequency filter and a filtered signal is output.



# Filter Concept

So what is inside the *grey box*?



How does it work?

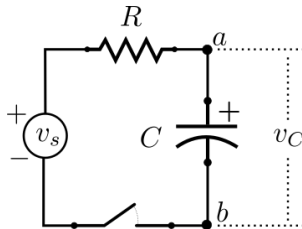
Interesting fact: The RC circuit used as first order filter is known as the Butterworth filter.

## Filter Concept

Filters are constructed from time-varying circuits. The most basic of which is the **RC filter**.

First Order Model

$$\tau \dot{y} + y = KA \sin(\omega t)$$

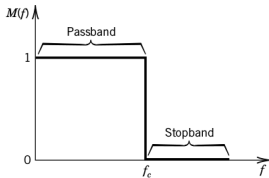


Response Equation

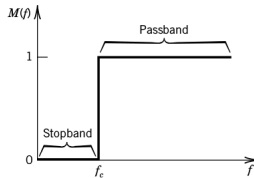
$$y(t) = Ce^{-\frac{t}{\tau}} + \frac{KA}{\sqrt{1 + (\omega\tau)^2}} \sin(\omega t - \tan^{-1}(\omega\tau))$$



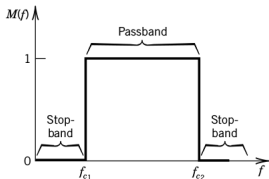
# High-Pass, Low-Pass, and Band-Pass



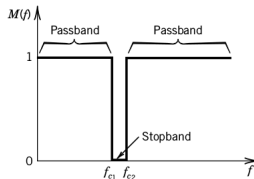
(a) Low-pass filter



(b) High-pass filter



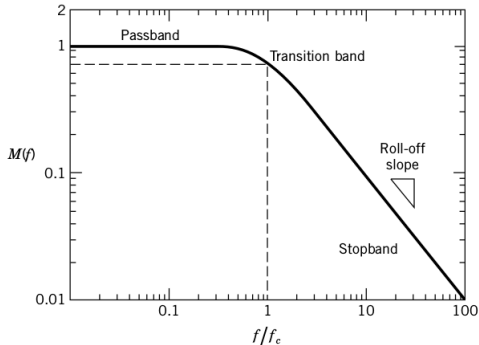
(c) Bandpass filter



(d) Notch filter

# High-Pass, Low-Pass, and Band-Pass

Physical frequency filters do not behave in an ideal manner as the previous figure shows. The filter characteristics are frequency dependent.



# Applications

Finally, what are filters used for?

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# MATLAB Activity

Class Activity: Complete the activity as an individual. Discussion with your peers is encouraged.

Overview: Consider the parameterized square wave shown in figure 1 as the input voltage to a first order filter. The input to the system is the source voltage and the output is the voltage across the capacitor.

- 1 Sketch the expected response of the RC circuit on the axes provided BEFORE viewing the analytical solution.
- 2 Use the MATLAB code 'filters\_activity.m' to view the analytical solution.
- 3 Do the expected results match the analytical results?
- 4 How does input frequency affect the output signal? In other words, what is shown as the input signal frequency is increased?
- 5 What could be changed in the filter circuit to reduce the affects of increasing input frequency?

## Class Activity - continued

